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E-425 March 1938

United States Department of Agriculture
Bureau of Entomology and Plant Quarantine

TOXICITY TESTS WITH SYNTHETIC ORGANIC COMPOUNDS AGAINST CULICINE MOSQUITO LARVAE

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Introduction and Literature Review

In the search for new insecticides the trend is toward organic compounds. Hargreaves (2)1/, testing a large number of metallic and nonmetallic organic compounds as stomach poisons against the caterpillars of Pieris rapae L. and Spilosoma lubricipeda Esp., found that the metallic organic compounds were relatively innocuous, and that, of the nonmetallic compounds tested, naphthalene derivatives were the most promising. McAlister and Van Leeuwen (6) tested a large number of inorganic and organic compounds against the larvae of Carpocapsa pomonella L. and the majority of compounds found to be effective were organic.

Hartzell and Wilcoxon (3,4) prepared a series of thiocyanogen compounds and tested their toxicity as sprays against Aphis rumicis L. In preliminary tests (3) their results with 15 such compounds indicated that γ- thiocyanopropylphenylether was the most promising. Later, testing five additional compounds of this type (4), they found trimethylene dithiocyanate to be definitely superior to any of the other thiocyanates tested.

Campbell and coworkers (1) tested 68 synthetic organic compounds, most of which contained sulphur, against mosquito larvae. They reported that 24 compounds equaled or exceeded nicotine in effectiveness, and of these dibenzofuran (diphenylene oxide) and dibenzothiophene (diphenylene sulphide) were the two most effective. These authors also state that J. W. Bulger reported phenothiazine (thiodiphenylamine) to be more toxic than rotenone, a finding that was later confirmed by the senior author.

1/ Reference is made by number (in parenthesis) to Literature Cited, p. 34.

Smith, Munger, and Siegler (7) also reported phenothiazine to be toxic to codling moth larvae.

Kagy (5) tested a number of nitrophenols as stomach poisons against the corn earworm, Heliothis obsoleta F., the armyworm, Cirphis unipuncta Haw., and the imported cabbage worm, Pieris rapae L., and reported 2,4-dinitro-6-cyclohexylphenol and its salts to be more toxic to the corn earworm than lead arsenate, although other compounds structurally related to the former had little toxicity.

The present investigation is a continuation of the work with synthetic organic compounds; in which mosquito larvae were used as the test insects.

Rearing Mosquito Larvae for Tests

Culicine mosquito larvae are easily reared and have proved exceedingly susceptible to organic compounds. With mosquito larvae as test insects differentiation can be quickly made between promising and unpromising compounds. Several species of culicine larvae may be used, the choice depending upon their abundance in a given locality. Culex pipiens L., C. nigripalpus Theob., C. salinarius Coq., and C. quinquefasciatus Say have been found equally susceptible to organic compounds, but the last species has been used chiefly in these studies.

Four-liter jars were used for rearing the larvae. Extreme variations in temperature were avoided by placing the rearing jars in a series of constant-temperature water baths.

Preliminary experiments running several weeks were made to determine whether yeast alone or in combination with blood albumin would be the better food for rearing the mosquito larvae. A mixture of the two substances was found to give a healthier and more active supply of larvae. The stock suspensions were made up as follows: One pound of baker's yeast was suspended in a liter of water, and a blood-albumin suspension was made up first in the form of a paste and then gradually thinned with water to give a 10-percent suspension. The yeast suspension was refrigerated at once, but the blood albumin was kept at room temperature for several days before being refrigerated. As soon as the eggs hatched in the rearing jars, 50 cc of a mixture of 2 parts of yeast suspension to 1 part of blood albumin was added. More of this mixture was added when necessary.

Overcrowding usually leads to a high mortality of young larvae. On the other hand, when too few larvae are present conditions become favorable for the formation of scum. The most favorable conditions were maintained by placing about 25 egg rafts in each rearing jar and keeping an even temperature throughout larval growth. The surface of the medium in the rearing jars was gone over twice each day with a cheesecloth net, to remove any scum. The medium was changed after the larvae reached the third instar.

Dispersing Compounds for Testing

The few compounds that were soluble in water were dissolved directly in that medium. Most of the others were soluble in acetone, and were introduced into the water by the addition of suitable aliquots of stock solutions in that organic solvent. Compounds not soluble in either water or acetone were mechanically dispersed as suspensions in the testing medium.

Testing Procedure

Fifty fourth-instar mosquito larvae were placed in a beaker of distilled water at 26° C., and the test material, either in solution in acetone or as a powder, was added. The mortality at the end of 16 hours was recorded.

Preliminary tests of each compound were made at five different concentrations, namely, 5, 10, 20, 40, and 100 parts per million parts of water. If the compound killed more than 50 percent of the larvae at any of these concentrations, it was retested to find the minimum concentration at which approximately 50-percent mortality was obtained. With materials of low toxicity the results obtained at 100 p.p.m. are given.

Effect of Acetone in Water on Mosquito Larvae

Since acetone-water solutions in certain proportions are in themselves toxic to mosquito larvae, it was necessary to determine the maximum concentration of acetone in water that was not toxic. This proved to be 1.5 cc per 100 cc. In the tests 0.5 to 1 cc of acetone per 100 cc of water was used. The concentration of the organic compound in acetone solution was usually 20 mg. per cc. When several compounds were to be tested at five or more concentrations simultaneously, the same quantity of acetone was used in each test. Water checks that contained the same quantity of acetone accompanied each series.

Discussion of Mode of Action of Compounds

When the acetone solutions of the organic compounds were added to water, they formed a clear solution, a fine suspension, or a heavy flocculent precipitate.

As mosquito larvae can ingest solid particles from water, it is evident that the organic compound may have acted as a contact poison either in solution or in suspension, or as a stomach poison either in solution or in suspension. Also it is possible that, if the material were entirely insoluble in the acetone-water solution and formed a precipitate that settled rapidly to the bottom of the beaker, and the particles were too large to be swallowed by the larvae, the compound would make very little, if any, contact with larvae, either internally or externally.

Compounds Tested and Results

The 400 compounds tested and the results obtained are summarized in table 1. The classification of the compounds reported is purely an arbitrary one. Obviously a great many of the compounds listed could be classed in any one of several groups. Therefore the authors do not attach very great weight to a comparison of the toxicity of one group with another or to relative toxicities within groups.

Table 2 divides each of the individual groups into percent toxic and percent non-toxic compounds.

In table 3 are listed the 23 compounds found most toxic in this series of tests.

Summary of Results

Four hundred synthetic organic compounds were tested against culicine mosquito larvae. Of these 220 proved effective enough to kill about 50 percent of the test insects in 16 hours at a concentration of 100 p.p.m., and 23 were adjudged to be at least as toxic as rotenone. The 10 most toxic compounds tested, all of which are considered to be better than rotenone, are phenothiazine, 4-(p-bromophenylazo)-resorcinol, 4-(p-bromophenylazo)-o-cresol, p-(p-bromophenylazo)-phenol, 4-(2,5-dichlorophenylazo)-o-cresol, 4-(p-bromophenylazo)-m-cresol, phenyl mercaptan, phenothioxin, p-tolyl mercaptan, and 6-methylphenothiazine.

Table 1. Toxicity of synthetic organic compounds to mosquito larvae

Name of compound	Concentration	Mode of application[1/]	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Hetrocyclic Compounds with Sulphur in 6-Membered Ring				
Phenothiazine, $C_{12}H_9NS$	1	A	100	No
Phenothioxin, $C_{12}H_8OS$	2	A	65	No
6-Methylphenothiazine, $C_{13}H_{11}NS$	2	A	48.5	No
Thioxanthydrol, $C_{13}H_{10}OS$	5	A	58	No
6-Ethylphenothiazine, $C_{14}H_{13}NS$	5	A	53	No
Phenothiazine-6-carboxylic-acid amylamide, $C_{18}H_{20}N_2OS$	10	I	94	Yes
Phenothiazine-6-carboxylic-acid amide, $C_{13}H_{10}N_2OS$	40	A	55	No
Thianthrene, $C_{12}H_8S_2$	80	A	49	Yes
α-Benzophenothiazine, $C_{16}H_{11}NS$	100	A	100	Yes
Phenothiazone, $C_{12}H_7NOS$	100	A	100	Yes
6-Acetylphenothiazine, $C_{14}H_{11}NOS$	100	I	94	Yes
Thioxanthene, $C_{13}H_{10}S$	100	A	64	Yes
Phenothiazine-6-carboxylic-acid o-chlorophenylamide, $C_{19}H_{13}ClN_2OS$	100	I	60	Yes
γ,γ'-Dibenzophenothioxin, $C_{20}H_{12}OS$	100	A	35	Yes
6-Chloro-1,4,2-benzothiazine-3(4)-one, C_8H_5ClNOS	100	A	29	Yes
Dibenzo-[γ,δ]-o-dithiin, $C_{12}H_8S_2$	100	A	20	No

1/ A, addition of acetone solution to water; I, suspension in water; W, solution in water.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocylic Compounds with Sulphur in 6-Membered Ring, cont.				
Bis(9-thioxanthyl) ether, $C_{26}H_{18}OS_2$	100	I	8	Yes
Phenothiazine-6-carboxylic-acid phenylamide, $C_{19}H_{14}N_2OS$	100	I	0	Yes
Phenothiazine-6-carboxylic-acid chloride, $C_{13}H_8ClNOS$	100	I	0	Yes
Thioxanthone, $C_{13}H_8OS$	100	I	0	Yes
Phenothiazine-S-oxide, $C_{12}H_9NOS$	100	A	0	Yes
Dithiocyanophenothiazine, $C_{14}H_7N_3S_3$	100	I	0	Yes
3-Nitrophenothioxin, $C_{12}H_7NO_3S$	100	A	0	Yes
3-Methyl-6-nitrophenothioxin, $C_{13}H_9NO_3S$	100	I	0	Yes
Phenothioxin-S-oxide, $C_{12}H_8O_2S$	100	A	0	Yes
Methylene blue	100	W	0	No
Thionin, $C_{12}H_{11}N_3S$	100	W	0	No

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocyclic Compounds with Sulphur in 5-Membered Ring				
Dibenzothiophene, $C_{12}H_8S$	3.3	A	60	No
1-Phenylbenzothiazole, $C_{13}H_9NS$	10	A	100	Yes
1-(Pyromucylmercapto)-benzothiazole $C_{12}H_7NO_2S_2$	20	A	44	Yes
4-Methyl-2(1)-thionaphthenone, C_9H_8OS	40	A	68	No
1-(Anilinomethylmercapto)-benzothiazole $C_{14}H_{12}N_2S_2$	40	A	88	No
1-(o-Toluinomethylmercapto)-benzothiazole $C_{15}H_{14}N_2S_2$	40	A	80	No
1-(p-Toluinomethylmercapto)-benzothiazole $C_{15}H_{14}N_2S_2$	40	A	50	No
Thiophene, C_4H_4S	40	I	0	No
1-Hydroxybenzothiazole, C_7H_5NOS	100	A	100	No
1-Mercapto-4-methylbenzothiazole, $C_8H_7NS_2$	100	A	100	No
3-Dimethylamino-4-methylthiazole, $C_6H_{10}N_2S$	100	A	90	No
1-(Benzoylmercapto)-benzothiazole, $C_{14}H_9NOS_2$	100	A	20	Yes
1-Anilinobenzothiazole, $C_{13}H_{10}N_2S$	100	A	8	Yes
3-Phenyl-2-phenylimino-4-thiazolidone, $C_{15}H_{12}N_2OS$	100	A	0	No
4-Methyl-2-keto-pyranothionaphthene, $C_{12}H_8O_2S$	100	I	0	Yes
1-Benzal-4-methyl-2(1)-thionaphthenone, $C_{16}H_{12}OS$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocyclic Compounds with Sulphur in 5-Membered Ring, cont.				
1-Fural-4-methyl-2(1)-thionaphthenone, $C_{14}H_{11}O_2S$	100	A	0	Yes
5-Dimethylamino-1-mercaptobenzothiazole, $C_9H_{10}N_2S_2$	100	I	0	Yes
Bis(1-benzothiazolyl) disulphide $C_{14}H_8N_2S_4$	100	I	0	Yes
spiro {Naphthalene-1(2),2'-naphtho-[1,2]-thioxol} -2-one, $C_{20}H_{12}O_2S$	100	A	0	Yes
Bis(1-benzothiazolyl)-phthalyl bisulphide, $C_{22}H_{12}N_2O_2S_4$	100	I	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocyclic Compounds with Sulphur Outside the Ring				
α-Phenyl-β-2-pyridylthiourea, $C_{12}H_{11}N_3S$	10	A	88	Yes
2-Thiocoumarin, C_9H_6OS	20	A	98	No
sym-Di-2-pyridylthiourea, $C_{11}H_{10}N_4S$	20	A	40	Yes
α-Phenyl-β-3-pyridylthiourea, $C_{12}H_{11}N_3S$	80	A	96	No
1-Benzoxazolemercaptan, C_7H_5NOS	100	A	95	No
1-Benzoxazolemercaptan acetate, $C_9H_7NO_2S$	100	A	49	Yes
9-Thioxanthone, $C_{13}H_8OS$	100	A	30	Yes
Nicotine salt of ammonium lauroyl diethylene glycol sulphate	100	A	24	No
2-Mercapto-1-phenylbenzimidazole, $C_{13}H_{12}N_2S$	100	A	20	Yes
N-Methyl-2(1)-thiopyridone, C_6H_7NS	100	I	0	No
2-Thiobarbituric acid, $C_4H_4N_2O_2S$	100	I	0	No
N-fural-S-(o-nitrophenyl)-sulphuramine, $C_{11}H_8N_2O_3S$	100	A	0	Yes
sym-Di-3-pyridylthiourea, $C_{11}H_{10}N_4S$	100	A	0	No

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocyclic Compounds with 5-Membered Ring, Not Containing Sulphur				
Dibenzofuran, $C_{12}H_8O$	5	A	80	No
p-Chloro-α-furalacetophenone, $C_{13}H_9ClO_2$	5	A	71	No
α-Fural-p-methylacetophenone, $C_{14}H_{12}O_2$	5	A	69	No
1,2,3,4-Tetrahydrocarbazole, $C_{12}H_{13}N$	5	A	61	Yes
2-Chlorodibenzofuran, $C_{12}H_7ClO$	5	A	50	No
2-Aminodibenzofuran, $C_{12}H_9NO$	5	A	48	No
1-Phenylbenzoxazole, $C_{13}H_9NO$	10	A	88	No
3-Chlorocarbazole, $C_{12}H_8ClN$	10	A	52	Yes
7-Acetyl-1,2,3,4-tetrahydrodibenzofuran, $C_{14}H_{14}O_2$	20	A	96	No
3-Acetyldibenzofuran, $C_{14}H_{10}O_2$	20	A	58	Yes
p-Tolyl ester of pyromucic acid, $C_{12}H_{10}O_3$	40	A	76	No
7-Amino-1,2,3,4-tetrahydrodibenzofuran, $C_{12}H_{13}NO$	40	A	60	Yes
9-Acetylcarbazole, $C_{14}H_{11}NO$	40	A	50	Yes
Pyromucamide, $C_5H_5NO_2$	80	A	92	No
1-(N-Phenylacetamido)-benzoxazole $C_{15}H_{12}N_2O_2$	100	A	94	No
1,2,3,4-Tetrahydro-7-nitrodibenzofuran, $C_{12}H_{11}NO_3$	100	A	20	Yes
2-Nitrodibenzofuran, $C_{12}H_7NO_3$	100	I	0	Yes
Phthalimide, $C_8H_5NO_2$	100	I	0	No

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocyclic Compounds with 5-Membered Ring, Not Containing Sulphur, cont.				
N,N'-di-3-pyridyl-α,α'-diamino-2-methylfuran, $C_{15}H_{14}N_4O$	100	A	0	No
3-Methyl-1-phenyl-5-pyrazolone, $C_{10}H_{10}N_2O$	100	A	0	No
β,α-Dinaphthofuran, $C_{20}H_{12}O$	100	A	0	Yes
3-Chloro-7-nitrodibenzofuran, $C_{12}H_6ClNO_3$	100	I	0	No
3-Nitrocarbazole, $C_{12}H_8N_2O_2$	100	A	0	Yes
9-Benzoyl-3-nitrocarbazole, $C_{19}H_{12}N_2O_3$	100	A	0	Yes
9-Benzoylcarbazole, $C_{19}H_{13}NO$	100	A	0	Yes
Difuralcyclopentanone	100	I	0	Yes
1-Anilinobenzoxazole, $C_{13}H_{10}N_2O$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Heterocyclic Compounds with 6-Membered Ring, Not Containing Sulphur				
5,5-Dimethylacridan, $C_{15}H_{15}N$	3.3	A	64	No
Xanthene, $C_{13}H_{10}O$	5	A	60	No
3,4-Benzocinnoline, $C_{12}H_8N_2$	10	A	86	No
Xanthone, $C_{13}H_8O_2$	10	A	64	No
Xanthydrol, $C_{13}H_{10}O_2$	10	I	52	No
Acridine, $C_{13}H_9N$	20	A	2/ 94	No
3,4-Benzocinnoline oxide, $C_{12}H_8N_2O$	20	A	90	No
10-Methyl-5(10)-acridone, $C_{14}H_{11}NO$	40	A	86	Yes
Di-2-pyridylamine, $C_{10}H_9N_3$	40	W	2/ 80	No
Coumarin, $C_9H_6O_2$	40	A	50	No
Diphenyl-3-pyridylamine, $C_{17}H_{14}N_2$	100	A	80	Yes
N,N'-Di-2-pyridyl-α,α'-diaminotoluene, $C_{17}H_{16}N_4$	100	A	58	No
1-Nitro-5(10)-acridone, $C_{13}H_8NO_3$	100	I	0	Yes
5-Ethyl-5-isoamylbarbituric acid, $C_{11}H_{18}N_2O_3$	100	I	0	No
Sodium salt of 5-ethyl-5-phenylbarbituric acid, $C_{12}H_{11}N_2NaO_3$	100	I	0	No
α(γ-Diphenyl-β-2-pyridylguanidine, $C_{18}H_{16}N_4$	100	A	0	Yes
Bis(9-xanthyl) ether, $C_{26}H_{18}O_3$	100	I	0	Yes
$\Delta^{9,9'}$-Bixanthene, $C_{26}H_{16}O_2$	100	I	0	Yes
Cyanuric acid, $C_3H_3N_3O_3$	100	I	0	No

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Amines, Imines, Amides, and Imides, Containing Sulphur				
Thiobenzanilide, $C_{13}H_{11}NS$	20	A	75	No
S-(o-Nitrophenyl)-sulphuramine, $C_6H_6N_2O_2S$	40	A	87	No
Thioacetanilide, C_8H_9NS	80	A	2/ 88	No
sym-Dibutylthiourea, $C_{13}H_{14}N_4S$	80	A	2/ 82	No
Thiocarbanilide, $C_{13}H_{12}N_2S$	80	A	2/ 76	No
α,β-Diphenylthiocarbohydrazide, $C_{13}H_{14}N_4S$	80	A	70	Yes
(2-Amino-4-chlorophenylmercapto) acetic acid, $C_8H_8ClNO_2S$	100	A	91	Yes
4-Chloro-2-nitrophenylsulphuramine, $C_6H_5ClN_2O_2S$	100	A	90	No
α,α'-Dimethylthiopropionamide, $C_5H_{11}NS$	100	A	26	No
Allylthiourea, $C_4H_8N_2S$	100	W	0	No
Thiopropionamide, C_3H_7NS	100	A	0	No
Thio-α-toluamide, C_8H_9NS	100	A	0	No
sym-Dibenzylthiourea, $C_{15}H_{16}N_2S$	100	A	0	No
asym-Dibenzylthiourea, $C_{15}H_{16}N_2S$	100	A	0	Yes
Bis(benzamido) sulphide, $C_{14}H_{12}N_2O_2S$	100	A	0	No
o-Nitrophenyl-p-toluino sulphide, $C_{13}H_{12}N_2O_2S$	100	A	0	Yes
N-benzal-S-(o-nitrophenyl)-sulphuramine, $C_{13}H_{10}N_2O_2S$	100	I	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Amines, Imines, Amides, and Imides, Containing Sulphur, Cont.				
4,4'-Bi-(o-thioanisidine), $C_{14}H_{16}N_2S_2$	100	A	0	Yes
sym-Di-1-naphthylthiourea, $C_{21}H_{16}N_2S$	100	I	0	Yes
sym-Bis(5,6,7,8-tetrahydro-1-naphthyl)-thiourea, $C_{21}H_{24}N_2S$	100	I	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Amines, Imines, Amides, and Imides, Not Containing Sulphur				
4-Chloro-2-nitrodiphenylamine, $C_{12}H_9ClN_2O_2$	2.5	A	53	No
1-Nitro-2-naphthylamine, $C_{10}H_8N_2O_2$	5	A	60	No
N-Phenyl-1-naphthylamine, $C_{16}H_{13}N$	5	A	58	Yes
N-o-Tolylanthranilic acid, $C_{14}H_{13}NO_2$	10	A	70	Yes
2,5-Dichloroaniline, $C_6H_5Cl_2N$	10	A	54	No
2-Chloro-4-nitroaniline, $C_6H_5ClNO_2$	20	A	2/98	No
p-Phenylaniline, $C_{12}H_{11}N$	20	A	89	No
2-Amino-4-chlorodiphenylamine, $C_{12}H_{11}ClN_2$	20	A	86	Yes
N-p-Tolylanthranilic acid, $C_{14}H_{13}NO_2$	20	A	50	Yes
2,4,6-Tribromoaniline, $C_6H_4Br_3N$	20	A	46	Yes
p-Nitrosodiphenylamine, $C_{12}H_{10}N_2O$	40	A	96	No
2-Nitro-p-toluidine, $C_7H_8N_2O_2$	40	A	84	No
N-m-Tolylanthranilic acid, $C_{14}H_{13}NO_2$	40	A	69	Yes
N-acetyl-p-toluidine, $C_9H_{11}NO$	40	A	2/62	No
N-(m-Chlorophenyl)-anthranilic acid, $C_{13}H_{10}ClNO_2$	40	A	54	Yes
α, α', γ-Triphenylguanidine, $C_{19}H_{17}N_3$	40	A	2/52	No
2-Naphthylamine, $C_{10}H_9N$	40	A	50	Yes

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m		Percent	
Amines, Imines, Amides, and Imides, Not Containing Sulphur, cont.				
α,γ-Diphenylguanidine, $C_{13}H_{13}N_3$	40	A	2/ 49	No
N-(o-Chlorophenyl)-anthranilic acid, $C_{13}H_{10}ClNO_2$	40	A	40	Yes
N-Benzalaniline, $C_{13}H_{11}N$	100	A	100	No
p-Iodoacetanilide, C_8H_8INO	100	A	100	No
1-Naphthylamine, $C_{10}H_9N$	100	A	98	No
p-Nitrosodimethylaniline, $C_8H_{10}N_2O$	100	I	98	Yes
o-Nitroaniline, $C_6H_6N_2O_2$	100	A	98	No
N-Formyldiphenylamine, $C_{13}H_{11}NO$	100	A	85	No
α-Cyanoguanidine, $C_2H_4N_4$	100	W	2/ 70	No
p-Nitroaniline, $C_6H_6N_2O_2$	100	A	54	No
N-Chloroacetyl-diphenylamine, $C_{14}H_{12}ClNO$	100	I	43	No
α-Chloroacetanilide, C_8H_8ClNO	100	A	40	No
N-Cyclohexylacetamide, $C_8H_{15}NO$	100	A	39	Yes
N-Cyclohexylbenzamide, $C_{13}H_{17}NO$	100	A	27	Yes
Benzanilide, $C_{13}H_{11}NO$	100	A	0	Yes
Benzamide, C_7H_7NO	100	A	0	No
Benzidine, $C_{12}H_{12}N_2$	100	A	0	No
p-Fluoroacetanilide, C_8H_8FNO	100	A	0	No
Atoxyl, $C_6H_7AsNNaO_3$	100	W	0	No
α,γ-Di-o-tolylguanidine, $C_{15}H_{17}N_3$	100	A	0	No

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Amines, Imines, Amides, and Imides, Not Containing Sulphur, Cont.				
p-Aminoacetanilide, $C_8H_{10}N_2O$	100	I	0	No
Triphenylamine, $C_{18}H_{15}N$	100	I	0	Yes
N-acetyldiphenylamine, $C_{14}H_{13}NO$	100	I	0	No
2,2'-Dinitrodiphenylamine, $C_{12}H_9N_3O_4$	100	A	0	Yes
N-(o-Nitrophenyl)-anthranilic acid, $C_{13}H_{10}N_2O_4$	100	A	0	Yes
Aniline salt of 2,4-dinitrodiphenylamine-6-carboxylic acid, $C_{19}H_{16}N_4O_6$	100	A	0	No
Acetone semicarbazone, $C_4H_9N_3O$	100	I	0	Yes
Benzaldehyde semicarbazone, $C_8H_9N_3O$	100	I	0	Yes
Anthranilic acid, $C_7H_7NO_2$	100	A	0	Yes
Acetoacetanilide, $C_{10}H_{11}NO_2$	100	A	0	No
p-Bromoaniline, C_6H_6BrN	100	A	0	No
Acetylurea, $C_3H_6N_2O_2$	100	A	0	No
m-Nitroaniline, $C_6H_6N_2O_2$	100	A	0	No
n-Butyl ester of allophanic acid, $C_6H_{12}N_2O_3$	100	A	0	No
N,N'Diphenylethylenediamine, $C_{14}H_{16}N_2$	100	A	0	Yes
N,N'-Diphenyl-p-phenylenediamine, $C_{18}H_{16}N_2$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Azo, Hydrazo, and Related Compounds				
4-(p-Bromophenylazo)-resorcinol, $C_{12}H_9BrN_2O_2$	1.42	A	70.3	Yes
4-(p-Bromophenylazo)-o-cresol, $C_{13}H_{11}BrN_2O$	1.42	A	51.7	Yes
p-(p-Bromophenylazo)-phenol, $C_{12}H_9BrN_2O$	1.66	A	88.2	No
4-(2,5-Dichlorophenylazo)-o-cresol, $C_{13}H_{10}Cl_2N_2O$	1.66	A	81	No
4-(p-Bromophenylazo)-m-cresol, $C_{13}H_{11}BrN_2O$	1.66	A	80.5	Yes
4-(p-Iodophenylazo)-o-cresol, $C_{13}H_{11}IN_2O$	2.5	A	93.2	Yes
4-(2,5-Dichlorophenylazo)-resorcinol, $C_{12}H_8Cl_2N_2O_2$	2.5	A	49	No
4-(2,5-Dichlorophenylazo)-m-cresol, $C_{13}H_{10}Cl_2N_2O$	2.5	A	48	No
4-(p-Nitrophenylazo)-resorcinol, $C_{12}H_9N_3O_4$	3.3	A	50	Yes
1-Phenylazo-2-naphthylamine, $C_{16}H_{13}N_3$	3.3	A	46	Yes
4-(2,5-Dichlorophenylazo)-2-cyclohexylphenol, $C_{18}H_{18}Cl_2N_2O$	5	A	2/ 68	Yes
Azobenzene, $C_{12}H_{10}N_2$	5	A	68	No
p-(2,5-Dichlorophenylazo)-phenol, $C_{12}H_8Cl_2N_2O$	5	A	66	Yes
4-(p-Bromophenylazo)-5,6,7,8-tetrahydro-1-naphthol, $C_{16}H_{15}BrN_2O$	5	A	55.3	Yes

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Azo, Hydrazo, and Related Compounds, Cont.				
1-(p-Bromophenylazo)-2-naphthylamine, $C_{16}H_{12}BrN_3$	5	A	44.3	Yes
Hydrazobenzene, $C_{12}H_{12}N_2$	10	A	92	Yes
1,3-Diphenyltriazene, $C_{12}H_{11}N_3$	10	A	70	Yes
4,4'-Azobis(o-toluidine), $C_{14}H_{16}N_4$	10	A	2/ 64	No
4-(o-Tolylazo)-o-toluidine, $C_{14}H_{15}N_3$	10	A	2/ 50	No
4-Phenylazo-m-cresol, $C_{13}H_{12}N_2O$	20	A	100	Yes
p-Phenylazophenol, $C_{12}H_{10}N_2O$	20	A	96	No
4-Phenylazo-o-cresol, $C_{13}H_{12}N_2O$	20	A	94	Yes
p-Phenylazoaniline, $C_{12}H_{11}N_3$	20	A	90	Yes
1-(p-Nitrophenylazo)-2-naphthol, $C_{16}H_{11}N_3O_3$	40	A	90	Yes
4-(2-Hydroxy-3,5-dinitrophenylazo)-6-m-tolylenediamine, $C_{13}H_{12}N_6O_5$	40	A	90	Yes
1-(3,5-dichloro-2-hydroxyphenylazo)-2-naphthol, $C_{16}H_{10}Cl_2N_2O_2$	40	A	84	Yes
1-(o-Tolylazo)-2-naphthylamine, $C_{17}H_{15}N_3$	40	A	50	Yes
(p-Hydroxyphenylazo)-pyrogallol, $C_{12}H_{10}N_2O_4$	100	A	100	No
p-Phenylazodiphenylamine, $C_{18}H_{15}N_3$	100	A	96	Yes
p-Phenylazodimethylaniline, $C_{14}H_{15}N_3$	100	A	75	Yes
1-(o-Anisylazo)-2-naphthol, $C_{17}H_{14}N_2O_2$	100	A	66	Yes

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Azo, Hydrazo, and Related Compounds, Cont.				
4-(2,5-Dichlorophenylazo)-3-ethoxyphenol, $C_{14}H_{12}Cl_2N_2O_2$	100	A	62	Yes
p-Iodoazobenzene, $C_{12}H_9IN_2$	100	A	52	Yes
4-(2,5-dichlorophenylazo)-2,5-xylenol, $C_{14}H_{12}Cl_2N_2O$	100	A	40	Yes
p,p'-Dichloroazoxybenzene, $C_{12}H_8Cl_2N_2O$	100	I	0	Yes
4-(2,5-Dichlorophenylazo)-guaiacol, $C_{13}H_{10}Cl_2N_2O_2$	100	A	0	Yes
4-(2,5-Dichlorophenylazo)-resorcinol dimethyl ether, $C_{14}H_{12}Cl_2N_2O_2$	100	A	0	Yes
4-(2,5-Dichlorophenylazo)-carvacrol, $C_{16}H_{16}Cl_2N_2O$	100	A	0	Yes
1,3-Bis(2,5-dichlorophenyl)-triazene, $C_{12}H_7Cl_4N_3$	100	A	0	Yes
1-(2,5-Dichlorophenylazo)-2-naphthol, $C_{16}H_{10}Cl_2N_2O$	100	A	0	Yes
4-(2,5-Dichlorophenylazo)-1-naphthol, $C_{16}H_{10}Cl_2N_2O$	100	A	0	Yes
[4-(2,5-dichlorophenylazo)-1-naphthyl)]-methyl ether, $C_{17}H_{12}Cl_2N_2O$	100	A	0	Yes
3-(2,5-Dichlorophenylazo)-p-cresol, $C_{13}H_{10}Cl_2N_2O$	100	A	0	Yes
6-(2,5-Dichlorophenylazo)-4-chloro-m-cresol, $C_{13}H_9Cl_3N_2O$	100	A	0	Yes
3-(2,5-Dichlorophenylazo)-6-chlorothymol, $C_{16}H_{15}Cl_3N_2O$	100	A	0	Yes
4-(2,5-Dichlorophenylazo)-thymol, $C_{16}H_{16}Cl_2N_2O$	100	A	0	Yes
4-Phenylazoresorcinol, $C_{12}H_{10}N_2O_2$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Azo, Hydrazo, and Related Compounds, cont.				
4-(1-Naphthylazo)-1-naphthol, $C_{20}H_{14}N_2O$	100	I	0	Yes
1-Phenylazo-2-naphthol, $C_{16}H_{12}N_2O$	100	A	0	Yes
1-(1-Naphthylazo)-2-naphthol, $C_{20}H_{14}N_2O$	100	I	0	Yes
1-[4-(o-Tolylazo)-2-tolylazo]-2-naphthol, $C_{24}H_{20}N_4O$	100	I	0	Yes
1-[p-(Phenylazo)-phenylazo]-2-naphthol, $C_{22}H_{16}N_4O$	100	I	0	Yes
4,4'-Azobis(o-anisidine), $C_{14}H_{16}N_4O_2$	100	A	0	Yes
p-(1-Naphthylazo)-dimethylaniline, $C_{18}H_{17}N_3$	100	A	0	Yes
p-(2-Naphthylazo)-dimethylaniline, $C_{18}H_{17}N_3$	100	A	0	Yes
2,4-Bis(phenylazo)-resorcinol, $C_{18}H_{14}N_4O_2$	100	I	0	Yes
2,2'-Azobis(thioanisole), $C_{14}H_{14}N_2S_2$	100	I	0	Yes
2,2'-Hydrazobis(thioanisole), $C_{14}H_{16}N_2S_2$	100	I	0	Yes
4-(2, 5-Dichlorophenylazo)-2,6-xylenol, $C_{14}H_{12}Cl_2N_2O$	100	A	0	Yes
1-[4-(m-Xylyl)-azo]-2-naphthol, $C_{18}H_{16}N_2O$	100	A	0	Yes
5-[p-(p-Hydroxyphenyl)-phenylazo]-salicylic acid, $C_{19}H_{14}N_2O_4$	100	A	0	No
o-(p-Dimethylamino-phenylazo)-benzoic acid, $C_{15}H_{15}N_3O_2$	100	A	0	Yes

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Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P. p. m. Hydrocarbons		Percent	
Phenanthrene, $C_{14}H_{10}$	5	A	47	No
Fluorene, $C_{13}H_{10}$	10	A	2/ 58	No
Biphenyl, $C_{12}H_{10}$	10	A	54	No
Acenaphthene, $C_{12}H_{10}$	20	A	94	No
Anthracene, $C_{14}H_{10}$	100	I	100	Yes
o-Diphenylbenzene, $C_{18}H_{14}$	100	A	95	Yes
m-Diphenylbenzene, $C_{18}H_{14}$	100	A	37	Yes
Retene, $C_{18}H_{18}$	100	A	10	Yes
1,3,5-Triphenylbenzene, $C_{24}H_{18}$	100	A	0	Yes
p-Diphenylbenzene, $C_{18}H_{14}$	100	I	0	Yes

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Phenols and Phenol Ethers				
2,4,5-Trichloro-6-nitrophenol, $C_6H_2Cl_3NO_3$	5	A	100	No
2,3,4,6-Tetrachlorophenol, $C_6H_2Cl_4O$	5	A	51	No
2-Cyclohexyl-4,6-dinitrophenol, $C_{12}H_{14}N_2O_5$	5	A	50	No
2-Bromo-4-phenylphenol, $C_{12}H_9BrO$	10	A	94	No
2-Chloro-4-phenylphenol, $C_{12}H_9ClO$	10	A	91	No
2,4,6-Trichlorophenol, $C_6H_3Cl_3O$	10	A	77	No
Diamylhydroquinone, $C_{16}H_{26}O_2$	10	A	2/ 58	No
p-Phenylphenol, $C_{12}H_{10}O$	10	A	56	No
2,4,6-Triiodophenol, $C_6H_3I_3O$	10	A	44	Yes
Pentachlorophenol, C_6HOCl_5	20	A	100	No
o-Phenylphenol, $C_{12}H_{10}O$	20	A	88	No
o-Cyclohexylphenol, $C_{12}H_{16}O$	20	A	82	No
3,5-Dinitro-o-cresol, $C_7H_6N_2O_5$	20	A	59	No
Salol, $C_{13}H_{10}O_3$	20	A	46	Yes
Sodium-2,3,4,5-tetrachlorophenoxide, C_6HCl_4NaO	20	W	42	No
p-Bromophenol, C_6H_5BrO	40	A	92	No
p-Hydroxybenzophenone, $C_{13}H_{10}O_2$	40	A	71	No
2,4-Dinitrophenol, $C_6H_4N_2O_5$	40	A	71	No
p,p'-Dimethoxydiphenylamine, $C_{14}H_{15}NO_2$	40	A	63	Yes
p-Cyclohexylphenol, $C_{12}H_{16}O$	40	A	50	Yes
p-Aminophenol, C_6H_7NO	40	A	2/ 39	No

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Phenols and Phenol Ethers, Cont.				
Sodium-2-chloro-6-phenylphenoxide, $C_{12}H_8ClNaO$	40	A	100	No
5,6,7,8-Tetrahydro-1-naphthol, $C_{10}H_{12}O$	40	A	98	No
1-Naphthol, $C_{10}H_8O$	40	A	96	No
2,4-Dinitro-6-phenylphenol, $C_{12}H_8N_2O_5$	100	A	100	No
Sodium-o-phenylphenoxide, $C_{12}H_9NaO$	100	W	100	No
2-Methyl-4,6-dinitroanisole, $C_8H_5N_2O_5$	100	A	100	No
3,4-Xylenol, $C_8H_{10}O$	100	A	75	No
2,6-Xylenol, $C_8H_{10}O$	100	A	62	No
1,1'-Bi-2-naphthol, $C_{24}H_{14}O_2$	100	A	50	Yes
1-Nitroso-2-naphthol, $C_{10}H_7NO_2$	100	I	40	No
p-Nitrosophenol, $C_6H_5NO_2$	100	W	0	No
Sodium salt of 2,4-dihydroxy-5-hexylbenzenesulphonic acid, $C_{12}H_{17}NaO_5S$	100	W	0	No
4,6-Dinitrosoresorcinol, $C_6H_4N_2O_4$	100	I	0	Yes
4,4'-Bi-o-anisidine, $C_{14}H_{16}N_2O_2$	100	A	0	No
N-acetyl-p-phenetidine, $C_{10}H_{13}NO_2$	100	A	0	No
2'-Hydroxy-2,4-dinitrodiphenylamine-6-carboxylic acid, $C_{13}H_9N_3O_7$	100	A	0	No
Catechol, $C_6H_6O_2$	100	A	0	No
o-Aminophenol, C_6H_7NO	100	A	0	No
m-Aminophenol, C_6H_7NO	100	A	0	No
p-Isopropoxydiphenylamine, $C_{15}H_{17}NO$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Nitro and Nitroso Compounds				
p-Dinitrobenzene, $C_6H_4N_2O_4$	5	A	51	No
p-Bromonitrobenzene, $C_6H_4BrNO_2$	5	A	48	Yes
Nitrosobenzene, C_6H_5NO	10	A	90	No
m-Dinitrobenzene, $C_6H_4N_2O_4$	10	A	87	No
m-Iodonitrobenzene, $C_6H_4INO_2$	20	A	96	No
o-Iodonitrobenzene, $C_6H_4INO_2$	40	A	98	No
p-Nitrophenylacetonitrile, $C_8H_6N_2O_2$	40	A	98	No
m-Bromonitrobenzene, $C_6H_4BrNO_2$	40	A	96	No
p-Chloronitrobenzene, $C_6H_4ClNO_2$	40	A	73	No
Dinitronaphthalene, $C_{10}H_6N_2O_4$	40	A	2/ 71	Yes
o-Bromonitrobenzene, $C_6H_4BrNO_2$	40	A	64	No
o-Dinitrobenzene, $C_6H_4N_2O_4$	40	A	54	No
o-Chloronitrobenzene, $C_6H_4ClNO_2$	100	A	100	No
m-Chloronitrobenzene, $C_6H_4ClNO_2$	100	A	100	No
p-Fluoronitrobenzene, $C_6H_4FNO_2$	100	A	88	No
p-Nitrobiphenyl, $C_{12}H_9NO_2$	100	A	47	Yes
2,2'-Dinitrobiphenyl, $C_{12}H_8N_2O_4$	100	A	40	Yes
p-Iodonitrobenzene, $C_6H_4INO_2$	100	A	0	Yes

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality After 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Aldehydes, Ketones, Thioaldehydes, and Thioketones				
2-Methylanthraquinone, $C_{15}H_{10}O_2$	5	A	81	No
α-Bromo-p-phenylacetophenone, $C_{14}H_{11}BrO$	5	A	2/ 65	Yes
Benzophenone, $C_{13}H_{10}O$	10	A	75	No
α-Hydroxy-p-phenylacetophenone formate, $C_{15}H_{12}O_3$	20	A	88	No
α-Hydroxy-p-phenylacetophenone chloroacetate, $C_{16}H_{13}ClO_3$	20	A	50	No
α-Hydroxy-p-phenylacetophenone acetate, $C_{16}H_{14}O_3$	20	A	48	Yes
Desoxybenzoin, $C_{14}H_{12}O$	100	A	100	Yes
Benzil, $C_{14}H_{10}O_2$	100	A	61	Yes
α-Hydroxy-p-phenylacetophenone chrysanthemum monocarboxylate, $C_{24}H_{26}O_3$	100	A	48	Yes
2,4,6-Trinitrobenzaldehyde, $C_7H_3N_3O_7$	100	I	40	No
γ-Thiobenzaldehyde, C_7H_6S	100	I	0	Yes
β-Thiobenzaldehyde, C_7H_6S	100	I	0	Yes
Trithioformaldehyde, $C_3H_6S_3$	100	I	0	No
2-Chloroanthraquinone, $C_{14}H_7ClO_2$	100	I	0	Yes
Anthraquinone, $C_{14}H_8O_2$	100	I	0	Yes
α-Chloro-p-phenylacetophenone, $C_{14}H_{11}ClO$	100	A	0	Yes
α,α'-Dichloro-p-phenylacetophenone, $C_{14}H_{10}Cl_2O$	100	A	0	Yes
Tri-(thiovanillin), $C_{24}H_{24}O_6S_3$	100	A	0	Yes
Tri-(thiovanillin benzoate), $C_{45}H_{36}O_9S_3$	100	A	0	Yes

2/ Some recovery.

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Aryl, Alkyl, and Aralkyl Halides				
p-Bromobiphenyl, $C_{12}H_9Br$	3.3	A	51	No
p-Chlorobiphenyl, $C_{12}H_9Cl$	5	A	84	No
4,4'-Difluorobiphenyl, $C_{12}H_8F_2$	5	A	50	Yes
p-Iodobiphenyl, $C_{12}H_9I$	10	A	66	Yes
p-Bromoidobenzene, C_6H_4BrI	20	A	90	No
p-Dibromobenzene, $C_6H_4Br_2$	20	A	52	No
2-Fluoronaphthalene, $C_{10}H_7F$	20	A	49	No
p-Chloroiodobenzene, C_6H_4ClI	40	A	98	Yes
p-Dichlorobenzene, $C_6H_4Cl_2$	40	A	95	No
Hexachlorobenzene, C_6Cl_6	40	A	60	No
p-Diiodobenzene, $C_6H_4I_2$	40	A	58	Yes
Hexachloroethane, C_2Cl_6	80	A	87	Yes
p-Fluorobiphenyl, $C_{12}H_9F$	100	A	94	No
4,4'-Dichlorobiphenyl, $C_{12}H_8Cl_2$	100	A	65	Yes
1,2,3,4,-Tetrachloronaphthalene, $C_{10}H_4Cl_4$	100	A	0	Yes
4,4'-Di-iodobiphenyl, $C_{12}H_8I_2$	100	A	0	Yes
4,4'-Dibromobiphenyl, $C_{12}H_8Br_2$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Sulphides, Disulphides, and Mercaptans				
Phenyl mercaptan, C_6H_6S	2	I	65.6	Oily
p-Tolyl mercaptan, C_7H_8S	2	I	52	Oily
m-Tolyl mercaptan, C_7H_8S	2.5	I	49	Oily
Triphenyl ester of trithioarsenious acid, $C_{18}H_{15}AsS_3$	3.3	A	85	No
Tri-p-tolyl ester of trithioarsenious acid, $C_{21}H_{21}AsS_3$	10	A	65	Yes
o-Tolyl mercaptan, C_7H_8S	10	I	58	Oily
Bis(diethylthionophosphono) disulphide, $C_8H_{20}O_4P_2S_4$	10	A	25	Yes
Sodium salt of benzylthioxanthic acid, $C_8H_7NaS_3$	20	A	66	No
Methyl-o-nitrophenyl sulphide, $C_7H_7NO_2S$	20	A	46	No
1-(1-Mercapto-2-naphthoxy)-2-naphthol, $C_{20}H_{14}O_2S$	100	A	90	Yes
4-Chloro-2-nitrophenyl sulphur bromide, $C_6H_3BrClNO_2S$	100	A	60	Yes
Diphenylmethylene-bis(mercaptoacetic acid), $C_{17}H_{16}O_4S_2$	100	A	10	No
S,S'-Dithio[1,1'-dithiobis(2-naphthol)], $C_{20}H_{14}O_2S_4$	100	A	0	Yes
Methylphenylmethylene-bis(mercapto-acetic acid), $C_{12}H_{14}O_4S_2$	100	A	0	Yes
Bis(p-nitrophenyl) sulphide, $C_{12}H_8N_2O_4S$	100	I	0	Yes
1-(o-Nitrophenylmercapto)-2-naphthol $C_{16}H_{11}NO_3S$	100	A	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Sulphides, Disulphides, and Mercaptans, Cont.				
2,4-Dihydroxy-2'-nitrodiphenyl sulphide, $C_{12}H_9NO_4S$	100	A	0	Yes
Acetonyl-o-nitrophenyl sulphide, $C_9H_9NO_3S$	100	A	0	No
(4-Chloro-2-nitrophenylmercapto)-acetic acid, $C_8H_6ClNO_4S$	100	A	0	No
α-(4-Chloro-2-nitrophenylmercapto)-acetophenone, $C_9H_8ClNO_3S$	100	I	0	Yes
Ethyl ester of α-(4-Chloro-2-nitrophenylmercapto)-acetoacetic acid, $C_{12}H_{12}ClNO_5S$	100	I	0	Yes
Bis(benzylmercaptothionoformyl) disulphide, $C_{16}H_{14}S_6$	100	I	0	Yes
Benzylmercaptomannose	100	A	0	No

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Acids, Alcohols, and Esters				
Phenyl ester of benzoic acid, $C_{13}H_{10}O_2$	10	A	50	Yes
4,6-Dinitro-o-cresol acetate, $C_9H_8N_2O_6$	100	A	100	No
p-Iodobenzoic acid, $C_7H_5IO_2$	100	I	90	Yes
Ammonium lauroyl diethylene glycol sulphate, $C_{16}H_{35}NO_7S$	100	W	21	No
p-Fluorobenzoic acid, $C_7H_5FO_2$	100	A	10	No
2-Chloro-3,5-dinitrobenzoic acid, $C_7H_3ClN_2O_6$	100	A	0	No
Borneol, $C_{10}H_{18}O$	100	A	0	No
Octa-acetyl sucrose, $C_{28}H_{38}O_9$	100	A	0	No
Hydrocinnamic acid, $C_9H_{10}O_2$	100	A	0	No
Dyestuffs				
Aurin, $C_{19}H_{14}O_3$	100	I	25	Yes
Indigo carmine	100	W	0	No
Sulphogene golden brown G, Schultz #1058	100	I	0	Yes
Sulphogene carbon 2-brom, Schultz #1078	100	I	0	Yes
Sulphogene yellow D, Schultz #1064	100	I	0	Yes
Sulphur brown R, extra	100	I	0	Yes
4,4',4''-Triaminotriphenylcarbinol, $C_{19}H_{19}N_3O$	100	I	0	No
Orcein, $C_{28}H_{24}N_2O_7$	100	I	0	No
Spirit blue, C.I. #689	100	I	0	Yes
Alkali blue 6B, C.I. #703	100	I	0	Yes
Induline spirit-soluble, C.I. #860	100	I	0	Yes
Nigrosine spirit-soluble, C.I. #864	100	I	0	Yes
Fluorescein, $C_{20}H_{12}O_4$	100	I	0	Yes

Name of compound	Concentration	Mode of application	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Thiocyano Compounds				
p-Iodophenyl ester of thiocyanic acid, C_7H_4INS	2.5	A	60.4	No
p-Chlorophenyl ester of thiocyanic acid, C_7H_4ClNS	2.5	I	53.6	Oily
p-Bromophenyl ester of thiocyanic acid, C_7H_4BrNS	2.5	A	53.5	No
4-Chloro-2-nitrophenyl ester of thiocyanic acid, $C_7H_3ClN_2O_2S$	5	A	88	No
p,p'-Dithiocyanodiphenylamine, $C_{14}H_9N_3S_2$	10	A	51	Yes
Polymerized thiocyanogen, (CNS).	40	I	50	Yes
p-Phenyl-α-thiocyanoacetophenone, $C_{15}H_{11}NOS$	100	A	16	Yes

Table 2.--Relative toxicity of different groups of compounds

Group	Number of compounds tested	Percentage of compounds nontoxic at 100 p.p.m.	Percentage of compounds toxic at indicated concentration (p.p.m.)											
			1	1.42	1.66	2	2.5	3.3	5	10	20	40	80	100
Heterocyclic compounds:														
With sulphur in 6-membered ring - - - - - -	27	51	4	-	-	7	-	-	7	4	-	4	4	19
With sulphur in 5-membered ring - - - - - -	21	48	-	-	-	-	-	5	-	5	5	24	-	13
With sulphur outside the ring - - - - - - - - -	13	54	-	-	-	-	-	-	-	8	15	-	8	15
With 5-membered ring not containing sulphur	27	45	-	-	-	-	-	-	22	7	7	11	4	5
With 6-membered ring not containing sulphur	19	37	-	-	-	-	-	5	5	16	11	16	-	10
Amines, imines, amides, and imides:														
Containing sulphur - -	20	60	-	-	-	-	-	-	-	-	5	5	20	10
Not containing sulphur-	53	48	-	-	-	-	2	-	4	4	9	17	-	16
Azo, hydrazo, and related compounds- - - - - - -	62	47	-	3	5	-	5	3	8	6	6	7	-	10
Hydrocarbons - - - - - -	10	40	-	-	-	-	-	-	10	20	10	-	-	20
Phenols and phenol ethers	41	27	-	-	-	-	-	-	7	15	15	22	-	14
Nitro and nitroso compounds- - - - - - -	18	17	-	-	-	-	-	-	11	11	5	39	-	17
Aldehydes, ketones, thioaldehydes, and thioketones- - - - - - - - -	19	53	-	-	-	-	-	-	10	5	16	-	-	16
Aryl, alkyl, and aralkyl halides- - - - - - - -	17	17	-	-	-	-	-	5	11	11	17	22	6	11
Sulphides, disulphides, and mercaptans - - - -	23	52	-	-	-	9	4	4	0	13	9	0	0	8
Acids, alcohols, and esters - - - - - - - - -	9	63	-	-	-	-	-	-	-	11	-	-	-	22
Dyestuffs- - - - - - - -	13	92	-	-	-	-	-	-	-	-	-	-	-	8
Thiocyano compounds- - -	7	0	-	-	-	-	43	-	14	14	-	14	-	15

Table 3. The most effective compounds tested

Name of compound	Concentration	Mode of application[1]	Mortality after 16 hours	Solid particles visible in water
	P.p.m.		Percent	
Phenothiazine	1	A	100	No
4-(p-Bromophenolazo)-resorcinol	1.42	A	70.3	Yes
4-(p-Bromophenolazo)-o-cresol	1.42	A	51.7	Yes
p-(p-Bromophenylazo)-phenol	1.66	A	88.2	No
4-(2,5-Dichlorophenylazo)-o-cresol	1.66	A	81	No
4-(p-Bromophenylazo)-m-cresol	1.66	A	80.5	Yes
Phenyl mercaptan	2	I	65.6	Oily
Phenothioxin	2	A	65	No
p-Tolyl mercaptan	2	I	52	Oily
6-Methylphenothiazine	2	A	48.5	No
4-(p-Iodophenylazo)-o-cresol	2.5	A	93.2	Yes
p-Iodophenyl ester of thiocyanic acid	2.5	A	60.4	No
p-Chlorophenyl ester of thiocyanic acid	2.5	I	53.6	Oily
p-Bromophenyl ester of thiocyanic acid	2.5	A	53.5	No
4-Chloro-2-nitrodiphenylamine	2.5	A	53	No
4-(2,5-Dichlorophenylazo)-resorcinol	2.5	A	49	No
m-Tolyl mercaptan	2.5	I	49	Oily
4-(2,5-Dichlorophenylazo)-m-cresol	2.5	A	48	No
5,5-Dimethylacridan	3.3	A	64	No
Dibenzothiophene	3.3	A	60	No
p-Bromobiphenyl	3.3	A	51	No
4-(p-Nitrophenylazo)-resorcinol	3.3	A	50	Yes
1-Phenylazo-2-naphthylamine	3.3	A	46	Yes

[1] A, addition of acetone solution to water; I, suspension in water; W, solution in water.

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